Statement of Work

I. Title: Development of Revised Input Data and Algorithms Used for Exposure Modeling of O_3 and Other Ambient Pollutants
Contractor Name: ICF, Incorporated
Contract #: EP-W-12-010
WA #: 2-26

II. Work Assignment Manager (WAM):

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III. Background:

EPA's Air Pollution Exposure (APEX) and Stochastic Human Exposure and Dose Simulation (SHEDS) models are two examples of complex, probabilistic, population-based tools EPA uses to estimate human exposures. These and other similar models incorporate a number of input data sets to estimate exposures, including population demographic and employment information (e.g., 2010 U.S. census-tract-level population), anthropometric attributes (e.g., body mass, height), physiological variables (e.g., metabolic equivalents of work or METS), time-location-activity patterns (i.e., EPA's Consolidated Human Activity Database or CHAD), among other input data. Also included in these models are various algorithms used to estimate intermediate physiological data that are important in calculating exposure concentrations and intake doses, such as statistical equations used for estimating resting metabolic rate (RMR), oxygen consumption rate (VO_2), expiratory (or total) ventilation rate (V_E), among other algorithms.

This statement of work (SOW) outlines tasks that will assist the work assignment manager (WAM) in revising and/or updating select input data and algorithms used by APEX and SHEDS in modeling exposures to ozone (O_3) and other ambient pollutants. More specifically, regarding input data, contractor assistance is needed expanding broadly-defined or aggregated CHAD activity codes to better

reflect a more specific set of diary-reported activities, developing new activity-specific METS for any newly defined activities, performing limited exposure model testing of the new activity coding and associated METS, and linking CHAD-relevant meteorological data to a limited set of new CHAD diaries. Further, assistance is needed in identifying, evaluating, and updating select algorithms used in estimating physiological variables (e.g., RMR, V_E).

The WAM is authorized to provide technical direction in accordance with the contract. This SOW instructs the Contractor to perform the following tasks which are described below.

IV. Description and Tasks:

Task #1: Work Plan

Within 20 days of the effective date of this WA, the Contractor shall submit a draft work plan outlining the approach to addressing this SOW, quality assurance procedures to be conducted, the schedule for the WA completion, and an estimate of the cost for completing the work. Following review by the WAM, the Contractor shall modify the work plan to reflect comments and recommendations by the WAM (if any exist). This final work plan, if modified, shall be submitted by the Contractor **within 7 days of receipt of WAM comments and recommendations**.

Task #2: Identification and Expansion of Broadly-Defined and/or Aggregated CHAD Activity Codes and Development of Metabolic Equivalents of Work (METS) for Newly Defined Activities

The WAM will provide to the Contractor, the latest version of the CHAD master database (i.e., >50,000 diary days) and the latest version of the CHAD METS mapping file, **no later than 7 days after approval of the Contractor work plan**. The Contractor shall perform the following steps to assist the WAM in revising the existing CHAD master events-level file to update/revise broadly-defined activity codes (e.g., CHAD code 11000, General household activities) or aggregated activity codes (e.g., CHAD code 17131, walk, bike, or jog-not in transit) to better reflect a more specific activity (e.g., walking), where such information is reported in the original diary event record.

a) The Contractor shall review the existing CHAD activities within the CHAD event-level data file for broadly-defined or aggregated activity codes that could potentially be expanded to include more specific activity descriptions. A determination of greatest potential impact can be used to identify these activities, and could generally be based on the combined effect of three factors (among others that may be identified by the Contractor in this review): (1) the range in the existing METS distribution of the broadly-defined activity, (2) the frequency and availability of specific activity information in the original diary activity entry that would better inform the development of a newly defined sub-activity code(s), and (3) sum total or percent of total duration the broadly-defined activity represents in CHAD. The Contractor shall provide to the WAM a draft technical memorandum that lists the CHAD activities/codes that could be expanded, and included in this list, the potential sub-activity descriptions/codes along with the supporting determination methodology and results **on or before June 16, 2014**.

b) Following review of the draft list of activity codes by the WAM **no later than June 23**, **2014**, the Contractor shall initiate a teleconference with the WAM **on or before June 30, 2014** to discuss selection of the broadly-defined activities to expand to include new activity descriptions and the new activity codes to be used. The Contractor shall summarize conclusions made in the teleconference regarding the newly identified activity codes selected by the WAM that are to be added to the CHAD database. The Contractor shall then revise the draft technical memorandum

in #1 above to include these conclusions regarding the new activities/codes selected and submit this final draft technical memorandum **on or before July 11, 2014**. Further, the Contractor shall update the CHAD diaries using the new CHAD activity codes and descriptions based on the final set selected by the WAM, where appropriate activity information exists in the diary event's original activity description. The Contractor shall provide the WAM with the revised CHAD event-level data file in .sas format **on or before August 11, 2014**.

c) Once the new activities and their respective codes have been selected and added to the CHAD event-level file, the Contractor shall develop draft METS distributions for these new activities. The Contractor shall begin the development by evaluating the parameters of the broadly-defined activity METS distributions and consider using METS information provided in the latest physical activity compendium (e.g., Ainsworth et al., 2011) and/or other similar exercise physiology references. The Contractor shall submit a draft technical memorandum to the WAM summarizing the METS distributions developed for the newly defined activities (i.e., form and variable parameters- e.g., upper and lower bounds, central tendency and variability estimates, where appropriate) along with their associated justifications or reasoning **on or before August 29, 2014**. Following review of the draft technical memorandum by the WAM, the WAM will provide comment and recommendations for improvement (if any exist) to the Contractor **no later than September 22, 2014.** The Contractor shall revise the draft document/distributions based on the WAM comments and recommendations (if any exist) and submit a final memorandum and the METS distributions file in .txt format to the WAM **on or before October 8, 2014**.

d) Following addition of the new activity information to the CHAD diary event-level file and CHAD METS distributions file, the Contractor shall first perform a limited test of the new files in an exposure model (e.g., APEX) to determine if operational. Then, following correction of errors (if any exist), the Contractor shall evaluate the impact of the newly developed files by comparing exposure model simulations performed using the new CHAD events/METS files versus using the prior files. These simulations should take into account, where possible, particular populations (e.g., children aged 12-18) or some other influential attribute (e.g., a particular season or month of year) that has been most affected by the development of the new activities. Further, a generalized simulation within a typically used study group (e.g., school-age children 5-18) and exposure duration (e.g., entire ozone season) shall be performed by the Contractor for additional context. In each of the simulations, output to be analyzed could include individual-level daily physical activity index (PAI) comparisons and/or another similar energy expenditure metric. The Contractor shall submit to the WAM a draft technical memorandum that summarizes methods used and simulation results **on or before November 7, 2014**.

Task #3: Update New CHAD Activity Pattern Data with New Activity Codes and Link CHAD-Related Meteorological Data to Diary Questionnaire File

The Contractor shall review the broadly-defined activity codes (as described above in Task 2) within a new set of diary data comprised of 23 persons, each having either 14-15 diary days and update this event-level file with the newly developed activity codes. The Contractor shall also add the following four meteorological (MET) data variables to the associated questionnaire file. The event-level and questionnaire data files will be provided to the Contractor by the WAM, **no later than November 7, 2014**. The Contractor shall use publically available sources such as the National Climatic Data Center (NCDC) to generate the following four variables in the defined units, and shall be linked to the geographic information already provided in the questionnaire file:

- Mean daily temperature (degrees F)
- Maximum 1-hour daily temperature (degrees F)
- Daily total rainfall (inches)
- Total daily rainfall event duration (hours)

The Contractor shall provide the final event-level and questionnaire files in a .sas format containing the newly-added activity information and MET data to the WAM **no later than December 12, 2014**.

Task #4: Evaluation and Consideration of Data Available and/or Approaches to Use for Updating of Existing Physiological Algorithms in APEX

The Contractor shall evaluate a limited set of the existing physiological algorithms in APEX in need of potential updating, including, but not limited to the equations used to estimate total ventilation rate or V_E (i.e., and based on Graham and McCurdy, 2005) and resting metabolic rate or RMR (i.e., and based on Schofield, 1985).

For example and considering the existing multiple linear regression equations used for V_E, the equations originally derived were stratified by several age categories (and gender), albeit based on observed but varying trends in V_E based on broadly-defined age groups. On occasion however, sharp discontinuities can result in estimated ventilation rates when comparing V_E for the last year of one age group to those estimated for the first year of the next age group (i.e., separate equation is used). One way to potentially address this issue is to refit to the original data to a new V_E equation, one that uses age as continuous function though recognizing also the differing trends across various age groupings. Alternatives could be considered, such as the review and adoption of relevant equations available in published literature or the supplementing of existing raw data sets that relate oxygen consumption rate (VO_2) to V_E with new data and development of similarly constructed equations to those currently used.

To assist the Contractor with evaluating the existing physiological algorithms in APEX, the WAM will provide the Contractor with a document summarizing a previously conducted review of the APEX algorithms **on or before July 11, 2014**. In addition, where relevant raw data have already been collected (e.g., the raw data used for developing the currently used V_E equations), the WAM will provide such raw data to the Contractor **on or before July 11, 2014**.

Following receipt of such information and data, the Contractor shall expand the prior review by performing a new literature search to identify any newly available studies relevant to potentially updating the existing physiological algorithms (including but not limited to new methods for developing equations, new data, and/or new equations). The Contractor shall provide the WAM with a draft technical memorandum **on or before August 8, 2014**, summarizing the results of this supplemental review including 1) possible new approaches and/or data to use in algorithm development, 2) anticipated implementation issues (i.e., APEX model modifications potentially needed), and 3) an estimate of the level of effort (man-hours) needed to revise/update each identified physiological algorithm.

V. QA Requirements:

Included in the work plan shall be an assessment of the quality of the data supporting the goals of the project. The Contractor shall also assess any limitations (if any) associated with the data and

analytical approaches used in the draft and final technical memoranda submitted and how these limitations may impact their use relative to this project's objectives.

VI. Deliverables:

A phone conference shall be arranged and conducted by the Contractor to discuss the initiation of the tasks with the WAM. Subsequently, phone conferences shall be conducted by the Contractor on a bi-weekly basis to discuss with the WAM the progress and any issues associated with the tasks. The Contractor shall adhere to the following schedule:

Task	Deliverable	Delivery Schedule
1	Work Plan	Within 20 days of effective date of WA
2	Draft tech memo: list of CHAD activity codes to modify	June 16, 2014
	Final tech memo: list of CHAD activity codes to modify	July 11, 2014
	Revised CHAD event-level file	August 11, 2014
	Draft tech memo: revised METs distributions	August 29, 2014
	Final tech memo: revised METS distributions	September 22, 2014
	Revised METS distributions file	October 8, 2014
	Draft tech memo: exposure simulations using revised CHAD data/METs distributions	November 7, 2014
3	Event-level and questionnaire files for new CHAD diary data	December 12, 2014
4	Draft tech memo: supplemental review of APEX physiological algorithms	August 8, 2014

VII. Reporting Requirements:

The Contractor shall provide monthly progress reports in accordance with the terms of the contract. The Contractor shall submit work products in electronic as well as hard copy form. In addition, the Contractor shall deliver to the WAM each draft and final report in electronic format that is readable by windows-based word-processing (Microsoft Word 2013), graphics (Microsoft PowerPoint 2013), spreadsheet (Excel 2013), and database (Access 2013) programs. The Contractor shall also provide electronic copies of reports in PDF format.

VIII. References:

Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR Jr, Tudor-Locke C, Greer JL, Vezina J, Whitt-Glover MC, Leon AS. (2011). 2011 Compendium of Physical Activities: a second update of codes and MET values. *Med Sci Sports Exerc*. 43(8):1575-81. doi: 10.1249/MSS.0b013e31821ece12.

Graham, S.E., McCurdy, T. (2005). Revised ventilation rate (VE) equations for use in inhalation-oriented exposure models. Report no. EPA/600/X-05/008 is Appendix A of US EPA (2009). Metabolically Derived Human Ventilation Rates: A Revised Approach Based Upon Oxygen Consumption Rates (Final Report). Report no. EPA/600/R-06/129F. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=202543.

Schofield, W. N. (1985). Predicting basal metabolic rate, new standards, and review of previous work. *Hum Nutr Clin Nutr*. 39C(S1):5-41.